Although nitrogen limitation is common in the Clark Fork River (especially in late summer) Pend Oreille Lake is primarily phosphorus limited, with occasional nitrogen limitation in late summer in the north lake. (Falter, see Attachment D.) According to Falter's review of data and literature, the fact that the Clark Fork River is often nitrogen limited probably has little bearing on the limiting factor in most of the south lake or mid-lake. Algal assays in Pend Oreille Lake through the fall 1984 indicated primary phosphorus limitation with secondary limitation by nitrogen at all sites (Woods 1991a). Algal assays in the lake through summer-fall 1986 indicated primary phosphorus limitation and secondary nitrogen limitation in the north and mid-lake but exclusive phosphorus limitation in the south lake (Gangmark and Cummins 1987). As with many large lakes, the growth of algae in near shore areas of Pend Oreille Lake is attributed to nutrient enrichment from shoreline and lake nearshore sources.

Chlorophyll-*a*, the primary photosynthetic pigment of algae and aquatic plants, is a widely cited and accepted indicator of trophic state (Carlson 1977, Ryding and Rast 1989). Mean chlorophyll-*a* concentrations were low and spanned a narrow range (Woods 1991a). Allowing for differences in analytical methods, it appeared current chlorophyll-*a* concentrations (1989/1990) differed little from those measured nearly twenty years ago (U.S. Geological Survey 1976.) It has been stated Pend Oreille Lake primary productivity has been inhibited by the Clark Fork River's temperature (Platts 1958), turbidity (Rieman 1976) or a combination of the two (Stross 1954). The Environmental Research Laboratory (1987) modeled chlorophyll-*a* production using the lake average total phosphorus concentration and the conclusion was that algae production was not excessive.

Several data sources exist for establishing nutrient targets for Pend Oreille Lake and the Clark Fork River at the Montana-Idaho state line. The most temporally and spatially robust data for Pend Oreille Lake was collected during 1989 and 1990. The data is comprised of about 300 water samples taken at five lake stations (Woods 1991a). Precision of the data was analyzed with duplicate samples for quality-assurance purposes. The U.S. Geological Survey streamflow and nutrient concentration sampling below Cabinet Gorge Dam during those same years is the most rigorous for the Clark Fork River for 1989/90. The most continuous long term monitoring record began in 1984 with MDEQ's Clark Fork monitoring program that included sampling at multiple river sites, including below Cabinet Gorge dam. In 1998, MDEQ's nutrient concentration data record was continued by the Council's Monitoring Committee (Land & Water 1999). The Technical Team considered all of these data sets in establishing nutrient targets for Pend Oreille Lake.

IV. Nutrient Targets, Loading Analysis and Allocation

A. Assumptions

The Technical Team developed and agreed to the following assumptions prior to development of the nutrient targets:

1. **Current lake *open water* water quality is acceptable.**
   Data supports the assumption that *open water* water quality, which is predominantly influenced by the Clark Fork River, has not changed statistically since the 1950's. Historical data show that, in general, the lake was oligotrophic (nutrient poor) during the early 1950's, mid-1970's, and late-1980's (Section 525 study3.) As noted above, the 1999 lake problem assessment concluded designated beneficial uses—water supply, recreation, salmonid spawning, cold-water biota, wildlife habitat and aesthetics—are being supported. The lake is afforded extra protection through the Special Resource Water designation whereby water quality cannot be lowered to the point that beneficial uses would be impacted. Therefore, the goal of **maintenance** of lake water quality, as recommended in the Section 525 report, is acceptable.

2. **The targets cover Pend Oreille Lake to its western boundary at the Long Bridge.**
   As delineated by USGS, the area covered by the targets includes all of Pend Oreille Lake from the mouth of the Clark Fork River inflow to the Long Bridge (Highway 95.) See map, Attachment C.

3. **The focus of the nutrient targets is protection of the quality of the lake's open water.**
   Open water and nearshore areas of the lake require separate management approaches. The targets recommended in this guidance are for open water, not for nearshore areas around the lake. Open water is defined as waters where the maximum depth is greater than 2.5 times water transparency as measured by Secchi depth. The targets address Montana and Idaho sources that contribute to nutrient loading of open water. Nearshore water quality will be addressed in the future as a separate issue.

4. **The targets are based on findings from the Section 525 water quality study and the long term MDEQ data set.** Conducted during 1989 and 1990, the 525 study comprises the most comprehensive and complete analysis for the Clark Fork River and Pend Oreille Lake to date. Studies of the lake included nutrient and hydrologic budgets, pelagic zone limnology, near shore productivity, and a nutrient load/lake response model. The Technical Team is confident in the use of the 525 data based on the quantity, quality and representativeness of the data generated. The team also utilized data from MDEQ's long-term monitoring record to develop targets that consider yearly nutrient variation.

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3 The Section 525 study concluded that extensive monitoring of the pelagic zone during the 1989 and 1990 water years indicated, on the basis of phosphorus, chlorophyll-*a* and nitrogen, Pend Oreille Lake was oligotrophic. Oligotrophy also was indicated by lakewide Secchi-disk readings; although Secchi-disk readings at the northern lake stations indicated mesotrophic or eutrophic conditions, this was due to inflow of turbid runoff delivered by the Clark Fork and not by increased biological production. (Hoelscher *et al.* 1993).

5. **The targets will be for total nutrients rather than soluble nutrients.**
Using a data base consisting of 200 rivers to relate algal densities to nutrient concentrations, Dodds and Smith (1995) concluded that total nutrients were a better predictor than soluble nutrients. In lakes, limnological studies show that total nutrients have a better correlation with algae than soluble nutrients, and that total nitrogen and total phosphorus relate better to seasonal and lakewide productivity (see discussion on nitrogen and phosphorus, Attachment D.)

6. **The targets are based on an area-weighted average.**
From the standpoint of nutrient cycling, the north and south areas of the lake are functionally distinct. The targets are protective of water quality throughout the open waters of the lake, and take into account differences between regional areas of the lake.

Four of the pelagic monitoring stations established for the Section 525 study were located at Bayview, Granite Point, Hope, and Contest Point (Woods 1991a). Area weighted values were based on surface area of lake segments as follows: segment 1 (Bayview and Granite), 70%; segment 2 (Hope and Contest Point), 30%. Using reported mean values for segment 1 and segment 2 from Woods, the average 1989 total phosphorus was 8.40 ug/l, and the 1990 value was 6.26 ug/l, with the average of these two years being 7.33 ug/l. Segments are delineated on the Pend Oreille Lake map, Attachment C.

Table 1. Area-weighted average calculations

Woods (1991)			
	Granite Segment 1 (70%)	Hope Segment 2 (30%)	Weighted Average
1989	8.1	9.1	8.40*
1990	5.9	7.1	6.26
Average	7.0	8.1	7.33

* e.g. (0.70 x 8.1) + (0.30 x 9.1) = 8.40

Further assumptions associated with development of the total phosphorus target are included in Attachment E, Pend Oreille Lake Total Phosphorus Targets.

7. **In-lake mixing of Clark Fork River inflow is an important factor, but is highly variable from year to year.**
Although mixing is an important factor, certain highly variable conditions make it difficult to predict how mixing will occur in the lake from year to year. The nutrient load/lake response model applied during the Section 525 studies was based on an annual nutrient budget and assumed that a major portion of phosphorus input from the Clark Fork River was routed through the northern segment of the lake and did not mix with the southern segment. This assumption was calibrated by in-lake tracking of the spring run-off plume from the Clark

Fork River. Using a transmissometer to measure transparency, USGS tracked the plume as it moved across the northern segment and out through the Pend Oreille River; additionally the tracking indicated that the overflow plume was less dense than lake water and stayed on top as it moved through. The results of the tracking were verified by sampling of conductivity at Cabinet Gorge and Albeni Falls. Other factors contributing to year-to-year variability in mixing, and thus to management uncertainties, include: years of very large flows when the loading could move to the south segment and go into storage; very heavy snow years when the run-off plume is much colder and could mix more with the lake as it moves through; or an extremely turbid run-off plume that could settle into the delta. (Woods, personal communication.)

8. **In addition to mixing, certain other important variables exist for which data cannot predict at this time the potential for impacts to the lake or to the targets.**
   These variables, which are the result of either (1) nutrient loading, or (2) lake expression of nutrient loading, or both, are:
   - -Introduced species (2)
   - -Food chain dynamics versus productivity (2)
   - -Hydrology (including water yield, water rights, dam operations) (1) (2)
   - -Lake internal dynamics (1) (2)
   - -Nutrient dynamics (upstream impoundments, and the lake itself) (1)
   - -Upstream management (Clark Fork VNRP, Flathead TMDL, new sources) (1)
   - -Meteorology (temperature, sunlight) (1) (2)
   - -Atmospheric deposition (1) (2)
   - -Ability to detect changes in the lake year-to-year (statistical challenge, sampling method) (2)

9. **The nutrient targets for Pend Oreille Lake are protective of lake water quality over the long term, while allowing for year-to-year variability.**
   Lake loading can be highly variable from year to year as a result of runoff and other controllable and uncontrollable factors. However, the lake's trophic status over the long term appears to be insensitive to small-to-moderate alterations in phosphorus and nitrogen inputs. The targets, therefore, accommodate short-term variations while affording long-term water quality protection for the open waters.

10. **The application of the targets within the State of Montana and the State of Idaho will be the responsibility of each of the states.**
    Although the sources of pollution may be different, it is assumed that Montana and Idaho have equal commitment and comparable ability to achieve and maintain their respective allocations.

B. Total Phosphorus

A simple mathematical model can be used to define the relation between annual total phosphorus loading and total phosphorus concentrations in the lake euphotic zone, the well-lighted portion of the water column where photosynthesis takes place. The model used for Pend Oreille Lake was originally developed by Vollenweider (1976). A conceptual representation of the expected relationship between phosphorus loading and in-lake concentration is further illustrated in a predictive graph (Hoelscher *et al.* 1993),
Attachment F.

As stated earlier, loading of total phosphorus is likely related to hydrologic events as phosphorus is adsorbed to soil particles. Frenzel (1991a) reported precipitation at Sandpoint, Idaho in 1989 was the same as the 1913-1988 average while the Clark Fork River discharge was slightly less (93%) than the average for 1928-1988. He presumed near average conditions also likely existed for ungaged drainages surrounding the lake. In 1990, precipitation was 105% and the river discharge was 116% of the long-term averages. Frenzel (1991b) estimated the total phosphorus load to Pend Oreille Lake was 292,000 kg in 1989 with the Clark Fork River contributing 80% and 361,000 kg in 1990 with the river contributing 83% of the total phosphorus load. Therefore, these data likely represent usual hydrologic and loading conditions. Temporal variability in the annual total phosphorus load to Pend Oreille Lake was 21% as measured by the relative percent difference (APHA 1998). Frenzel (1991b) estimated overall error, inclusive of errors in the hydrologic budget and estimated errors in the collection and analysis of the nutrient samples, was about 16% of the total load to Pend Oreille Lake and River upstream from Albeni Falls Dam. Land & Water (1999) estimated the accuracy for estimates of mean annual phosphorus concentration in the Clark Fork River to be within 30% based on a sample size of 18 per year.

Woods (1991a) reported lakewide total phosphorus concentrations of 8.4ug/l in 1989 and 6.2 ug/l in 1990. Relative percent difference, inclusive of temporal variability—comprised of annual loading differences as well as in-lake nutrient cycling—and measurement error, was 32%. Measurement error was estimated at 7.2%. Total phosphorus concentrations did vary spatially with higher concentrations in the northern end of the lake in closer proximity to the Clark Fork River inflow. Separation of Pend Oreille Lake into basins based on these data is not recommended because of the uncertainty of the Clark Fork River inflow annual mixing characteristics, the overwhelming dominance of the southern lake basin volume of water, and any real basin differences in total phosphorus concentration would likely be eclipsed by temporal variability.

The average total phosphorus load (328,651 kg) to Pend Oreille Lake accurately predicted within measurement error the observed average area-weighted euphotic zone lake total phosphorus concentration (7.3 ug/l). These data are realistic as the lake as a whole has a multiple year hydraulic residence time. Combining the 1989 and 1990 hydrologic data accounted for about 85% of the water volume in Pend Oreille Lake.

Many researchers have presented trophic state classification systems. The system described by Ryding and Rast (1989) was used for these analyses. Their classification system identified trophic state boundaries for oligotrophic waters as four micrograms per liter total phosphorus and ten micrograms per liter for mesotrophic waters. For any waterbody, there is a gradation in water quality along these boundaries. Sonzogni *et al.* (1976) estimated the phosphorus residence time at about three times the hydraulic residence time. This is about ten years for Pend Oreille Lake. Assuming total phosphorus loads in the mesotrophic range occurring once in a ten year period may provide for undesirable water quality conditions, a gradation for mesotrophic characteristics was set at plus or minus ten percent of the value reported by Ryding and Rast (1989).

An euphotic total phosphorus concentration of 7.3 ug/l is recommended as a target for Pend Oreille Lake. This value should either be derived from a south-lake sampling location, due to the dominance of lake volume, or better from an area-weighted average of a south-lake and north-lake location. The latter would better represent any significant changes in the major inflow, the Clark Fork River. Assuming a combined temporal variability and measurement error of 30%, euphotic total phosphorus concentrations representative of mesotrophic conditions should be detectable.

An annual total phosphorus load of 259,500 kg/yr is recommended as a target for the Clark Fork River at the Montana-Idaho state line. This value was derived by taking the average annual total phosphorus load for the 1989-90 period reported by Frenzel (1991b). An annual total phosphorus load of 69,151 kg/yr is recommended for local sources in Idaho based on the nutrient budget developed by Frenzel. The 1989-90 record is considered to be representative based on basin water yield and precipitation, which was near normal for the period.

Independent confirmation of USGS 1989-1990 total phosphorus load estimates for the Clark Fork is provided by MDEQ monitoring data. Data collected from 1984-1999 were used to estimate 1989-1990 total phosphorus loads using the FLUX model (Walker 1996). The FLUX algorithm (Method 6) employed a regression model using all data for the period of record applied to individual daily flows to estimate annual loads. Using MDEQ data (n=166), the estimated loads for 1989-1990 were 216,400 kg and 273,904 kg, respectively (Land & Water 2000). The average of these values is 245,152 kg, which corresponds to a relative percent difference of 5.7% compared with USGS value of 259,500 kg (Frenzel 1991b). This relative difference is within measurement and estimation error for the load values, and does not represent a statistically significant difference.

The USGS value of 259,500 kg is supported by MDEQ data, and is recommended as the target value to maintain consistency with the calibrated lake model (Woods 1991b) that forms the basis for lakewide total phosphorus concentrations.

A worksheet outlining how the phosphorus load allocation was calculated is included as Attachment G.

C. Total Nitrogen

Because historical data did not show strong evidence for support of a nitrogen target for the lake's open water, the Technical Team enlisted the assistance of Dr. C. Michael Falter (University of Idaho) to conduct a literature review and recommend an approach to nitrogen for Pend Oreille Lake. The results of Dr. Falter's findings and conclusions (Nitrogen vs. Phosphorus Limitation in Pend Oreille Lake Open Water) are included in Attachment D and can be summarized as follows:

- Although nitrogen limitation has occasionally been recognized in oligotrophic systems, nitrogen limitation is generally associated with eutrophic waters.
- Nitrogen limitation is more likely to occur in aquatic environments where nitrogen loss through de-nitrification is common, such as in shallow waters. Because the lake's photic zone is far removed from sediment influence and its hypolimnion is oxygen-rich, Pend Oreille Lake would be expected to show little nitrogen limitation. This suggests that nitrogen limitation should not be a significant issue in the lake, especially in its central and southern basins.
- Based on existing data, the lake appears to be primarily phosphorus-limited with occasional nitrogen limitation in late summer in the north lake. Mid- and south-lake regions show little or no nitrogen limitation.
- The ratio of total nitrogen to total phosphorus (TN:TP) serves as an indicator of a waterbody's nutrient balance and the potential for algae growth. Low TN:TP ratios are common in eutrophic lakes and blue-green algae blooms are rare when the TN:TP ratio is higher than 29:1. Algal blooms are more likely at low ratios.
- A TN:TP ratio greater than 15:1 indicates phosphorus limitation.
- During the 525 studies, TN:TP ratios in the lake's euphotic zone averaged 18:1 throughout the lake.

Based on Falter's findings, the Technical Team agreed that a nitrogen target is not justified at this time. However, because nitrogen-to-phosphorus ratios are an important indicator of potential changes to water quality, a TN:TP ratio of 15:1 is recommended as the desirable lower limit to avoid the occurrence of algal blooms in Pend Oreille Lake.

In-lake monitoring of the TN:TP ratio is recommended and an observed ratio of 15:1 or lower would serve as a trigger for reconsideration of setting a target for nitrogen.

D. Monitoring Plan Scope of Work

Introduction

A monitoring program must be in place to evaluate if the concentration and loading targets are being met and if those targets are effective in protecting the lake's water quality. In order to develop such a program, the Technical Team considered various scenarios of target exceedances and the subsequent management actions that might follow each of these scenarios. The scenarios included **episodic** (one year above the targets,) **short term** (three consecutive years above the targets) and **long term** (a ten-year average greater than the targets.) This review led the team to the following conclusions:

1. Recognizing that annual nutrient loading is inherently variable due to natural factors, periodic short-term exceedances of the loading targets may occur. However, the lake's buffering capacity has been adequate to accommodate natural variability (see discussion, Section 4). Therefore, a one-year exceedance of the targets would not trigger a management action. Of greater concern is the need to identify and assess the longer-term trend toward lake eutrophication as evidenced by increased loading.

2. A short-term exceedance of the targets (three consecutive years of total phosphorus load increases at the border that are above the targets by greater than 10%) should serve as a "red flag," triggering concern that a trend may be developing. Actions to be taken should include:
   - A review of the data to ensure confidence;
   - A review of factors such as: annual runoff/water yield and ambient concentrations;
   - A review of lake response data;
   - An identification of causes (natural and human-induced) and sources (point and nonpoint; Montana and Idaho);
   - A determination of error factor; and
   - Consideration of development and implementation of a management strategy.

3 A long-term exceedance of the targets (a ten-year average total phosphorus concentration in the lake greater than 7.3 ug/l) will warrant the development of a management strategy to curb nutrient loading. Actions to be taken should include:
   - A review of data to ensure convincing evidence of a change in trend;
   - A review of causes (natural and human-induced) and sources (point and nonpoint; Montana and Idaho); and
   - Implementation of a management strategy

Because of the need to assess trends that are based on good science, the team recommends an annual monitoring program to build a record for the long-term. The products of the program will be an annual status report, an assessment of time trends, and an analysis of the associated causes. The objective of the program will be to detect real trends early enough so that appropriate and effective actions can be taken to protect Pend Oreille Lake water quality. Data collected during the monitoring program may potentially suggest re-definition of long-term targets and trends to protect the lake.

Monitoring Goals and Objectives

The purpose of monitoring is to generate reliable information on water quality trends and status for watershed managers. Analysis of approximately 10 years of historical nutrient data for the Clark Fork watershed provided statistical design criteria for the load monitoring program at Cabinet Gorge (Land & Water 1995).

Three principle water quality monitoring objectives are defined for Pend Oreille Lake. These include 1) estimation of annual total phosphorus loads to Pend Oreille Lake from the Clark Fork River, 2) assessment of open water, lake-wide average total phosphorus concentrations in the euphotic zone and 3) assessment of trends in Pend Oreille Lake trophic status (Carlson Index). These objectives will be coordinated with the existing Clark Fork-Pend Oreille water quality monitoring program. A future objective will be developed to evaluate attainment of phosphorus loading targets for the Idaho portion of the watershed, which will be based on a nutrient management strategy for the lake.

For the purposes of determining achievement of the states' respective loading targets, it is recommended that Montana evaluate sampling data from the Clark Fork River at the border (Cabinet Gorge) and that Idaho develop and implement a program—as noted above—that will quantify nutrient loading from point, nonpoint and atmospheric sources within the Idaho portion of the watershed.

Individual management-monitoring goals are outlined with appropriate statistical criteria in the following sections.

1.1.1 Clark Fork River, Total Phosphorus Load Targets (Montana Sources)

MANAGEMENT GOAL:	Maintain Montana phosphorus loading targets
MONITORING GOAL:	Compare annual total phosphorus loads to target
DEFINITION OF TARGET:	259,500 kg annual load of total phosphorus
STATISTICAL METHODOLOGY:	Shewhart-Cusum Control Chart
STATISTICAL HYPOTHESIS:	Ho: Estimated load within control limits, short/long term Ha: Estimated load outside control limits, short/long term
DATA ANALYSIS RESULT:	Conclusions regarding achievement of targets
INFORMATION PRODUCT:	Management goal met when estimated load is within control chart baseline values

1.1.2 Pend Oreille Lake, Total Phosphorus Concentration

MANAGEMENT GOAL:	Maintain pelagic water quality

MONITORING GOAL: Evaluate departures from baseline phosphorus concentration
DEFINITION OF WATER QUALITY: Total phosphorus, euphotic zone, area-weighted lake annual average
DEFINITION OF TARGET: Mean concentration equal to or less than baseline of 7.3 ug/l
STATISTICAL METHODOLOGY: Two sample t-test, or Mann-Kendall if non-normal distribution, 90% C.L.
STATISTICAL HYPOTHESIS: Ho: No statistical difference from baseline exists
Ha: Statistical departure from baseline exists
DATA ANALYSIS RESULT: Conclusions regarding departure of annual mean concentration from baseline conditions
INFORMATION PRODUCT: Management goal met if no statistically significant difference from baseline value exists

1.1.3 Pend Oreille Lake, Trophic Status

MANAGEMENT GOAL: Maintain pelagic water quality
MONITORING GOAL: Detect significant trends in trophic status
DEFINITION OF WATER QUALITY: Carlson index (Total P, Secchi Depth, Chl a).
DEFINITION OF TREND: Presence of statistically significant trend in 10 year period
STATISTICAL METHODOLOGY: Seasonal Kendall with Sen slope estimate
STATISTICAL HYPOTHESIS: Ho: No trend exists
Ha: Trend exists
DATA ANALYSIS RESULT: Conclusions regarding presence of trends
Provide estimate of trend magnitude
INFORMATION PRODUCT: Management goal met when no trend exists, or indicates improvement

1.1.4 Pend Oreille Lake, Total Phosphorus Load Targets (Idaho Sources)

MANAGEMENT GOAL: Maintain Idaho phosphorus loading targets
MONITORING GOAL: Compare annual total phosphorus loads to target
DEFINITION OF TARGET: 69,151 kg annual load of total phosphorus
STATISTICAL METHODOLOGY*:
STATISTICAL HYPOTHESIS*:
DATA ANALYSIS RESULT*:
INFORMATION PRODUCT*:

*To be developed upon completion of a lake nutrient management strategy.

Monitoring Stations

Monitoring stations are located at sites of historical USGS data collection, and are representative of mid lake and north lake zones.

Table 2. Monitoring Locations

Site	Latitude	Longitude	Area Represented
Granite Point (2.5 mi SW) USGS Station 2000257	48-04'56"	116-28'33"	South-Central Lake, 70% area; 232.2 km²
Hope (1 mile W) USGS Station 2000259	48-15'00"	116-20'30"	North Lake, 30% area; 99.9 km²

Monitoring Parameters

Water samples for total phosphorus, total nitrogen, soluble reactive phosphorus and total soluble inorganic nitrogen are collected from the euphotic zone (2.5x Secchi depth). Nitrogen variables will be monitored to evaluate N:P ratios (see discussion, Pages 16-17.) If resources allow, it is recommended that soluble phosphorus and nitrogen also be analyzed to provide a more robust data set that may help with identification of nutrient sources. Samples will be taken using a 1000 ml Kemmerer sampler, and depth integrated from the euphotic zone. Chlorophyll-*a* samples will be collected from the same two locations. Field parameters will also include Secchi depth measured at Hope, Granite and Bayview. Detailed sampling methods will be contained in a sampling and analysis plan currently being prepared by Land & Water and to be approved by Montana and Idaho.

Table 3. Sample volumes, containers, preservation and holding times for lake nutrient samples

Analyte	Sample Volume	Container	Preservation	Holding Time
Total P and N	125 ml	polyethylene	add H_2SO_4 to pH<2, cool to <4°C	28 days
Total Soluble inorganic N4 (NO_2+NO_3+NH_4)	125 ml	polyethylene	filter, add H_2SO_4 to pH<2, cool to <4°C	28 days
Soluble Reactive Phosphorus1	125 ml	polyethylene	filter, cool to <4°C	48 hours
Chlorophyll-*a*	1000 ml	amber polyethylene	Filter, freeze	7 days

Monitoring and Assessment Program Costs

Funding for the following monitoring program elements will need to be covered:

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4 Optional monitoring variables

- Monitoring for the above parameters at two stations (Hope and Granite);
- Applicable data from the Council's existing Clark Fork-Pend Oreille monitoring program;
- Trend analyses and reporting; and
- Source loading analysis from Idaho

E. Targets, Loading, Allocation and Monitoring Summary

Based on a review of water quality data, the Technical Team concluded that water quality in the lake's *open water* has not changed significantly since the 1950's. The team therefore concurred with the conclusion of the Section 525 study that maintenance of current water quality is an appropriate goal. To set an in-lake target that would maintain open lake water quality, the team utilized data from the Section 525 studies and MDEQ's long-term monitoring record, along with modeling methods for calculating the correlation between oligotrophic and mesotrophic lake conditions. This target is 7.3 ug/l total phosphorus to protect and maintain open lake water quality.

To meet the in-lake concentration target of 7.3 ug/l total phosphorus, the team set a target for total loading to Pend Oreille Lake of 328,651 kg/yr total phosphorus. To address contributions to the lake's open water from both the Clark Fork River and local sources, the total load is allocated as follows: 259,500 kg/yr total phosphorus from Montana (Clark Fork River at Montana/Idaho state line) and 69,151 kg/yr total phosphorus from the Pend Oreille Lake watershed in Idaho.

Based on existing data, the lake appears to be primarily phosphorus limited, therefore the in-lake target and allocations focus on total phosphorus. However, the in-lake nitrogen to phosphorus (N:P) ratio will be monitored. An observed N:P ratio of 15:1 or lower may indicate a shift toward nitrogen limitation in the lake and will serve as a trigger to initiate the setting of a target for total nitrogen.

A water quality monitoring program is essential to determine if the goal of maintaining open lake water quality is being met. The team has developed a program that includes sampling design to evaluate annual phosphorus loading to Pend Oreille Lake from the Clark Fork River and in-lake concentrations of total phosphorus. Monitoring will also provide the means to detect long-term trends in trophic status of the lake, since it is critical to detect real trends early enough so that appropriate and effective actions can be taken to protect Pend Oreille Lake water quality.

V. Attachments

- Attachment A: Glossary

- Attachment B: Reference List
- Attachment C: Map of Pend Oreille Lake
- Attachment D: Nitrogen vs. Phosphorus Limitation in Pend Oreille Lake Open Water, C. M. Falter
- Attachment E: Pend Oreille Lake Total Phosphorus Targets, B. Anderson and B. Hoelscher
- Attachment F: Predictive Graph
- Attachment G: Phosphorus Load Allocation Worksheet, B. Anderson